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Generation mean analysis for fruit yield and its components in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]

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Abstract
In the present investigation, nature and magnitude of gene action was analyzed in six generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) of three crosses [ABG 1 × DBG 5 (cross 1), NDBG 132 × DBG 6 (cross 2) and Pusa Naveen × DBG 5 (cross 3)] of bottle gourd. On the basis of individual scaling tests, additive-dominance model was adequate in ABG 1 x DBG 5 and Pusa Naveen x DBG 5 for number of fruits per plant; and in ABG 1 x DBG 5 for fruit yield per plant. For the remaining character-cross combinations, additive-dominance model was found inadequate for description of variation in generation means. The (h) and (l) components had opposite sign in all the crosses for all characters except for number of fruits per plant in NDBG 132 x DBG 6, for average fruit weight per plant in Pusa Naveen x DBG 5, and for days to last picking in ABG 1 x DBG 5. Thus, these cross presuming largely complementary type of epistasis. Remaining crosses for all traits presuming largely duplicate type of epistasis. It would be concluded from the present study that fruit yield per plant and its component traits studied in three bottle gourd crosses were governed by additive, dominance, digenic, epistasis and digenic epistasis gene effects along with duplicate type of gene action. When additive as well as non-additive gene effects are involved, a breeding scheme efficient in exploiting both types of gene effects should be employed. Bi-parental mating could be followed which would facilitate exploitation of both types of gene effects simultaneously for genetic improvement of fruit yield and its component traits in bottle gourd.

Keywords: Additive, bottle gourd, dominance, epistasis, generation mean analysis

Introduction
Bottle gourd (*Lagenaria siceraria* (Mol.) Standl. 2n = 2x = 22), is one of humankind's first domesticated plants. It is also known as white flower gourd, Ghiakadoo or Lauki, is an important cucurbitaceous vegetable crop belonging to family *Cucurbitaceae* and subfamily *Cucurbitoidae*. Bottle gourd has greater economic importance. It is commonly grown for vegetable and it has medicinal value to human being. It can be used for making sweets (e.g. halva, kheer, petha and burfi) and pickle. A decoction made from the leaf is very good medicine for curing jaundice. The pulp is good for overcoming constipation, cough, night blindness, and as an antidote against certain poisons. The plant extract is used as a cathartic and the seed are used in dropsy. The fruit contain 0.2 per cent protein, 0.1 per cent fat, 2.5 g carbohydrates, 0.5 g mineral matter, 0.3 mg thiamine, 0.01 mg riboflavin, 0.2 mg niacin, 12 k cal energy per 100 g fresh weight and 11 mg of vitamin C per 100 g fresh weight.

Bottle gourd is highly cross pollinated crop. Cross pollination per cent ranges from 60 to 80 per cent, results into large variation in shape and size of fruits varies from very long slender to thick and round. The information on the nature of gene action would be helpful in predicting the effectiveness of selection from segregating materials. A distinct knowledge of the type of gene action and its magnitude are of fundamental importance to a plant breeder, which helps in formulation of an effective and sound breeding programme. The main purpose of bottle gourd breeding is to increase fruit yield. However, fruit yield is a very complex character which is governed by polygenes and affects many genetic and non-genetic factors. Therefore, the choice of appropriate breeding method for enhancing fruit yield potential through component traits largely depends upon the information on the nature and magnitude of gene effects present in the populations. Although diallel and line × tester analysis have been used the most, but they do not provide the estimates of non-allelic interactions. Generation mean analysis (Mather and Jinks, 1982) [7], besides providing estimates of main gene effects (additive and non-additive), also provide estimates of non-allelic (digenic) interactions *viz*., additive × additive [i], additive × dominance [j] and dominance × dominance [l] cross-wise. This helps in the proper understanding and selection of potential parents or crosses for the pedigree selection or heterosis exploitation.

Materials and methods

Plant material

The experimental materials comprised of six basic generations *viz*., P_1, P_2, F_1, F_2, BC_1 and BC_2 of three cross namely ABG 1 × DBG 5, NDBG 132 × DBG 6 and Pusa Naveen × DBG 5 were made between five parents by manual emasculation and pollen transfer. F1 plants were selfed to obtain seed for the F_2 generation and backcrossed with their respective parents to generate BC_1 and BC_2 generations. Thus, a total of six generations were obtained.

Field trial

The six generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) for each population were planted during *kharif* 2019. Six populations were planted in compact family block design (CFBD) with three replications. Each replication was divided in to three compact blocks, each consists of single cross and blocks were consisted of six plots of six basic generation of each cross. The crosses were assigned to each block and six generations of a cross were relegated to individual plot within the block. Each block was comprised of eleven rows consisting single row each of P_1, P_2 and F_1; four rows of F_2 and two rows each of BC_1 and BC_2 generations with 10 plants in each row. Each row spaced 2 m apart and plant to plant distance within row was 1 m. Fertilizers were applied as per recommended doses and other cultural practices were carried out at regular intervals during the course of experimentation. The observations were recorded on five competitive and randomly selected plants from P_1, P_2 and F_1, ten plants from BC_1 and BC_2 generations and twenty plants from F_2 generations in each replication for days to opening first female flower, days to opening first male flower, number of node bearing first female flower, number of node bearing first male flower, vine length (m), days to first picking, fruit length (cm), fruit equatorial diameter (cm), number of fruits per plant, average fruit weight per plant (kg), days to last picking and fruit yield per plant (kg).

Statistical analysis

The analysis of variance was performed to test the significance of difference among the genotypes for all the characters following fixed effect model as suggested by Panse and Sukhatme (1985) [8]**,** Individual scaling test will be done as per Mather (1949) [6]. Joint scaling test will be done as per Cavalli (1952) [1]. Gene effects will be calculated by using model as per Jinks and Jones (1958) [5] and Cavalli (1952) [1].

Results and discussion

The analysis of variance among families (Table 1) indicated significant mean square differences among all the three families (crosses) for all the characters studied. Likewise, the mean squares among progenies within each family revealed that the variations among the six generations were significant for all the characters studied in all the three crosses.

Components of generation means based on additive-dominance model

To decide the adequacy of additive-dominance model, simple scaling tests given by Mather (1949) [6] and joint scaling test of Cavalli (1952) [1] were applied to test adequacy of three and six-parameter models. Whenever, this additive-dominance model failed to explain the variation in generation means, six-parameter model using weighted least square method was used to estimate main, digenic and linked digenic effects. The results of individual scaling test A, B, C of Mather (1949) [6] and joint scaling test D of Cavalli (1952) [1] showed that additive-dominance model was adequate in cross cross 1 (ABG 1 x DBG 5) and 3 (Pusa Naveen x DBG 5) for number of fruits per plant; and in cross 1 (ABG 1 x DBG 5) for fruit yield per plant. Patel (2010) [9] observed adequacy of additive – dominance model in about 22.22 per cent cases of his study For the remaining character-cross combinations, additive-dominance model was found inadequate for description of variation in generation means. it was observed that all the three or two or any of the individual scaling tests A, B or C were significant for these characters in all the three crosses indicating the presence of epistasis. The application of joint scaling test expressed significant chi-square values for these traits further confirming involvement of digenic interaction parameters in the inheritance of all these characters. The failure of additive- dominance model was attributed mainly to the epistasis. Cockerham (1959) [2] postulated that the epistatic gene action is common in the inheritance of quantitative traits and there is no sound biological reason as to why this type of gene action should be less common for quantitative traits.

Components of generation means based on three parameter model (Cavalli, 1952) [1] as well as Jinks and Jones (1958) [5].

The results obtained from three parameter model of additive-dominance by Jinks and Jones (1958) [5] as well as Cavalli (1952) [1] revealed that parameter 'm' was found significant in all the crosses in which three parameter model was satisfied for various traits. The significant 'm' suggested that all the generations differed significantly from one another for their performance (Table 2 to Table 13).

As per three parameter model of Jinks and Jones (1958) [5], additive (d) gene effect was found significant and positive for days to opening first female flower in ABG 1 x DBG 5 and Pusa Naveen x DBG 5; for days to opening first male flower in ABG 1 x DBG 5; for number of node bearing first female flower and number of node bearing first male flower in NDBG 132 x DBG 6 and Pusa Naveen x DBG 5; for days to first picking in ABG 1 x DBG 5 and Pusa Naveen x DBG 5; for fruit length in ABG 1 x DBG 5 and NDBG 132 x DBG 6; for fruit equatorial diameter in Pusa Naveen x DBG 5; for number of fruits per plant in ABG 1 x DBG 5 and Pusa Naveen x DBG 5; for average fruit weight per plant in NDBG 132 x DBG 6 ; and for days to last picking in ABG 1 x DBG 5, NDBG 132 x DBG 6 and Pusa Naveen x DBG 5.

As per three parameter model of Jinks and Jones (1958) [5], dominance (h) gene effect was found significant and positive for number of node bearing first male flower in NDBG 132 x DBG 6; for days to first picking in Pusa Naveen x DBG 5; for fruit equatorial diameter in ABG 1 x DBG 5, NDBG 132 x DBG 6 and Pusa Naveen x DBG 5; and for days to last picking in Pusa Naveen x DBG 5.

As per three parameter model of Cavalli (1952) [1], additive (d) gene effect was found significant and positive for days to opening first female flower in ABG 1 x DBG 5 and Pusa Naveen x DBG 5; for days to opening first male flower in ABG 1 x DBG; for number of node bearing first female flower and number of node bearing first male flower in NDBG 132 x DBG 6 and Pusa Naveen x DBG 5; for days to first picking in ABG 1 x DBG 5, NDBG 132 x DBG 6 and Pusa Naveen x DBG 5; for fruit length in ABG 1 x DBG 5 and NDBG 132 x DBG 6; for fruit equatorial diameter in Pusa Naveen x DBG 5; for number of fruits per plant in ABG 1 x DBG 5 and Pusa Naveen x DBG 5; for average fruit weight per plant in NDBG 132 x DBG 6; for days to last picking in NDBG 132 x DBG 6 and Pusa Naveen x DBG 5; and for fruit yield per plant in NDBG 132 x DBG 6.

As per three parameter model of Cavalli (1952) [1], dominance (h) gene effect was found significant and positive for number of node bearing first female flower and number of node bearing first male flower in ABG 1 x DBG 5; for vine length and fruit length in ABG 1 x DBG 5, NDBG 132 x DBG 6 and Pusa Naveen x DBG 5; for days to first picking in ABG 1 x DBG 5; for number of fruits per plant in ABG 1 x DBG 5 and Pusa Naveen x DBG 5; and for average fruit weight per plant in NDBG 132 x DBG 6 and Pusa Naveen x DBG 5.

The magnitude of dominance (h) gene effect was higher than that of additive (d) gene effect for most of the traits in all the crosses evaluated, suggesting greater importance of dominance effect in expression of the characters studied. For the exploitation of dominance effect, non-conventional breeding procedure might be adopted. Wani *et al.* (2009) [10] and Gautam and Yadav (2017) [3] also observed higher magnitude of dominance effect for most of the traits studied including fruit yield per plant in bottle gourd.

Components of generation means based on six parameter model (Hayman, 1958) [4]

When the simple additive model failed to explain the variation among generation means, a six-parameter model involving three digenic interaction parameters ([i], [j] and [l]) was applied on the line of Hayman (1958) [4] and by Cavalli (1952) [1]. The results obtained from six parameter model of Hayman (1958) [4] revealed that parameter 'm' was found significant in all the crosses evaluated for various traits.

The results obtained from six parameter model revealed that in addition to the significance of main gene effects m, (d) and (h); all the three digenic interactions *viz*., additive x additive (i), additive x dominance (j) and dominance x dominance (l) were significant for number of node bearing first male flower in ABG 1 x DBG 5; for vine length in NDBG 132 x DBG 6 and Pusa Naveen x DBG 5; for fruit length in NDBG 132 x DBG 6 and Pusa Naveen x DBG 5; for fruit equatorial diameter in ABG 1 x DBG 5 and Pusa Naveen x DBG 5. The goodness of fit for six parameter model could not be tested in the present study owing to no degrees of freedom left for testing chi-square estimates for various characters. The perfect fit solution of Hayman (1958) [4], therefore, does not provide a general method for testing the adequacy of digenic interaction model. Such a method would require experiment with more number of family means than the minimum number necessary for fitting a full digenic interaction model.

The hybrids showing full digenic interaction had significant and positive dominance (h) component. Also the magnitude of dominance (h) component was higher than that of additive (d) effects for almost all the characters studied in all the crosses, which indicated greater importance of dominance effect in the expression of these characters.

The (h) and (l) components had opposite sign in all the crosses for all characters except for fruit equatorial diameter in DBG 5 x DBG 6; for number of fruits per plant in NDBG 132 x DBG 6, for average fruit weight per plant in Pusa Naveen x DBG 5 and for days to last picking in ABG 1 x DBG 5. Thus, these cross presuming largely complementary type of epistasis. Remaining crosses for all traits presuming largely duplicate type of epistasis.

Estimate of additive (d) and dominance (h) components varied from cross to cross and character to character. The variable expression of gene effect in different crosses might be due to the genetic makeup of a particular cross and the effect of environmental condition on the expression of different traits.

Components of generation means based on six parameter model (Cavalli (1952) [1]

The results obtained from six parameter model on the line of Cavalli (1952) [1] revealed that in addition to the significance of main gene effects m, (d) and (h); and all the three digenic interactions *viz*., additive x additive (i), additive x dominance (j) and dominance x dominance (l) were significant (either positive or negative) in Pusa Naveen x DBG 5 for days to opening first female flower; ABG 1 x DBG 5 for number of node bearing first female flower; NDBG 132 x DBG 6 for number of node bearing first male flower; NDBG 132 x DBG 6 and Pusa Naveen x DBG 5 for vine length; ABG 1 x DBG 5, NDBG 132 x DBG 6 and Pusa Naveen x DBG 5 for fruit length; and ABG 1 x DBG 5 and Pusa Naveen x DBG 5 for fruit equatorial diameter. These results indicated that six parameter model of Cavalli (1952) [1] was perfect fit and adequate with significance of all the six gene effects.

On the basis of results of adequacy of additive – dominance model and on the basis the results from six parameter model on the line of Cavalli (1952) [1], wherein the three and six parameter model was found to be perfect fit and adequate, the remaining character-cross combinations out of total character-cross combinations, in which any of the additive x additive (i), additive x dominance (j) and dominance x dominance (l) type of interaction was non-significant were reanalyzed after the removal of non-significant effects one-by–one starting with that of lowest magnitude until the remaining inter-allelic interaction became significant. The results of reanalysis revealed the best fitting four or five parameter model on line of Cavalli (1952) [1]. In addition to the significance of main gene effects, m, (d) and (h); additive x additive (i) type of interaction was noted significant in ABG 1 x DBG 5 for days to opening first female flower, in Pusa Naveen x DBG 5 for number of node bearing first female flower and in ABG 1 x DBG 5 and NDBG 132 x DBG 6 for days to first picking and days to last picking; additive x dominance (j) type of interaction was noted significant in ABG 1 x DBG 5 for vine length; and dominance x dominance (l) type of interaction was found significant in Pusa Naveen x DBG 5 for days to first picking and days to last picking; and in ABG 1 x DBG 5 for average fruit weight per plant. Thus, in these crosses, four parameter model on the line of Cavalli (1952) [1] was found to be perfect fit and adequate.

While, in addition to the significance of main gene effects, m, (d) and (h); additive x additive (i) type of interaction and dominance x dominance (l) type of interaction was noted significant in NDBG 132 x DBG 6 for days to opening first female flower; in NDBG 132 x DBG 6 and Pusa Naveen x DBG 5 for days to opening first male flower, in NDBG 132 x DBG 6 for number of node bearing first female flower and in ABG 1 x DBG 5 for number of node bearing first male flower; additive x dominance (j) type of interaction and dominance x dominance (l) type of interaction was noted significant in Pusa Naveen x DBG 5 for number of node bearing first male flower; and additive x additive (i) type of interaction and additive x dominance (j) type of interaction was noted significant in NDBG 132 x DBG 6 for fruit equatorial diameter. Thus, in these crosses, five parameter model on the line of Cavalli (1952) [1] was found to be perfect fit and adequate.

Cross ABG 1 x DBG 5 for days to opening first male flower; NDBG 132 x DBG 6 for number of fruits per plant, average fruit weight per plant and fruit yield per plant and Pusa Naveen x DBG 5 for average fruit weight per plant and fruit yield per plant; showing the presence of higher order epistasis and/or linkage.

Table 1: Analysis of variance (mean squares) between crosses and between generations within cross of six generations for different characters in bottle gourd

Source of variation	d.f.	Days to opening first female flower	Days to opening first male flower	No of node bearing first female flower	No of node bearing first male flower	Vine length (m)	Days to first picking
Replications	2	1.72*	1.37*	0.09	0.01	0.001	0.151
Crosses	4	1.24*	1.40*	1.55*	0.74*	0.141**	0.719**
Error	8	0.25	0.26	0.22	0.16	0.001	0.089
$\chi 2$		NS	NS	NS	NS	S	S
ABG 1 x DBG 5							
Replications	2	1.13	2.46	0.23	0.14	0.004	0.055
Generations	5	6.76**	5.61*	11.56**	5.27*	0.302**	5.229**
Error	10	0.52	1.27	1.89	0.95	0.007	0.303
NDBG 132 x DBG 6							
Replications	2	0.84	2.16	2.32	0.67	0.003*	1.261
Generations	5	5.70*	6.21*	4.00*	7.55**	0.194**	2.781**
Error	10	1.22	1.67	1.06	0.67	0.001	0.371
Pusa Naveen x DBG 5							
Replications	2	2.04	0.82	0.36	0.83	0.003	0.001
Generations	5	7.17**	2.75**	3.37*	3.84*	0.110**	8.079**
Error	10	1.03	0.33	0.86	0.87	0.001	0.280

Table 1: Conti….

Source of variation	d.f.	Fruit length (cm)	Fruit equatorial diameter (cm)	Number of fruits per plant	Average fruit weight per plant (kg)	Days to last picking	Fruit yield per plant (kg)
Replications	2	0.09	0.003	0.02	0.0013	0.19	0.002
Crosses	4	47.75**	0.558**	0.30**	0.0062*	0.72**	0.018**
Error	8	0.05	0.002	0.01	0.0011	0.06	0.001
$\chi 2$		S	S	NS	S	NS	S
ABG 1 x DBG 5							
Replications	2	0.07	0.010	0.02	0.0240**	0.34	0.026
Generations	5	172.85**	0.540**	0.77**	0.0077*	4.99**	0.076**
Error	10	0.24	0.008	0.06	0.0022	0.52	0.009
NDBG 132 x DBG 6							
Replications	2	1.29	0.002	0.03	0.0026*	0.77	0.002
Generations	5	13.16**	0.447**	0.584**	0.0037**	2.57*	0.033**
Error	10	1.98	0.013	0.094	0.0006	0.49	0.005
P. Naveen x DBG 5							
Replications	2	0.18	0.018	0.02	0.0017	0.01	0.001
Generations	5	12.79**	0.428**	0.65**	0.0021*	7.71**	0.074**
Error	10	0.61	0.009	0.07	0.0006	0.30	0.003

*, ** = Significant at 5% and 1% levels, respectively
Chi-square for Bartlett's test of homogeneity of error variances, S= Significant and NS = Non-significant

Table 2: Estimates of scaling tests, gene effects and best fitting model for days to opening first female flower of three crosses in bottle gourd

Scaling tests/gene effects	ABG 1 x DBG 5 (cross 1)			NDBG 132 x DBG 6 (cross 2)			Pusa Naveen x DBG 5 (cross 3)		
	Individual scaling test								
A	0.60	±	0.72	-0.53	±	0.46	-4.47**	±	0.56
B	-0.40	±	0.58	1.80**	±	0.50	-1.53**	±	0.57
C	-3.07*	±	1.25	3.13**	±	1.10	1.00	±	1.39
D	-1.63*	±	0.62	0.93	±	0.51	3.50**	±	0.67
	Gene effects in different models								
	Three parameters model (Jinks and Jones, 1958)								
M	47.50**	±	1.25	50.83**	±	1.04	58.13**	±	1.35
(d)	0.50**	±	0.15	-0.90**	±	0.19	1.00**	±	0.13
(h)	3.10	±	3.04	-5.36*	±	2.37	-22.73**	±	3.07
	Three parameters model (Cavalli, 1952)								
M	50.74**	±	0.14	49.07**	±	0.16	50.80**	±	0.12
(d)	0.53**	±	0.14	-1.37**	±	0.14	0.65**	±	0.11
(h)	-3.89**	±	0.31	-2.71**	±	0.30	-3.62**	±	0.28
$\chi 2$	8.98*			24.21**			76.22**		
	Six parameter model (Hayman, 1958)								
M	48.18**	±	0.25	48.30**	±	0.23	50.01**	±	0.30
(d)	1.00**	±	0.36	-2.06**	±	0.22	-0.46	±	0.30

(h)	0.36	±	1.30	-4.76**	±	1.07	-9.73**	±	1.39
(i)	3.26*	±	1.24	-1.86	±	1.02	-7.00**	±	1.35
(j)	0.50	±	0.40	-1.16**	±	0.29	-1.46**	±	0.33
(l)	-3.46	±	1.93	0.60	±	1.43	13.00**	±	1.80
	Six parameters model (Cavalli, 1952)								
M	47.50**	±	1.25	50.83**	±	1.04	58.13**	±	1.35
(d)	0.50**	±	0.15	-0.90**	±	0.19	1.00**	±	0.13
(h)	3.10	±	3.04	-5.36*	±	2.37	-22.73**	±	3.07
(i)	3.26**	±	1.24	-1.86	±	1.02	-7.00**	±	1.35
(j)	1.00	±	0.80	-2.33**	±	0.59	-2.93**	±	0.66
(l)	-3.46	±	1.93	0.60	±	1.43	13.00**	±	1.84
Type of epistasis	**Duplicate**			**Duplicate**			**Duplicate**		
	Best fitting model (Cavalli, 1952)								
M	49.46**	±	0.59	50.44**	±	0.46		-	
(d)	0.57**	±	0.14	-0.90**	±	0.19		-	
(h)	-2.13*	±	0.84	-4.40**	±	0.64		-	
(i)	1.37*	±	0.61	-1.49**	±	0.52		-	
(j)	-			-2.36**	±	0.59		-	
(l)	-			-				-	
χ2	4.00			0.18			-		

* and** Significant at 5 and 1 per cent levels, respectively

Table 3: Estimates of scaling tests and gene effects for days to opening first male flower of three crosses in bottle gourd

Scaling tests/gene effects	ABG 1 x DBG 5 (cross 1)			NDBG 132 x DBG 6 (cross 2)			Pusa Naveen x DBG 5 (cross 3)		
	Individual scaling test								
A	-0.93	±	0.63	-0.60	±	0.53	-0.07	±	0.84
B	-0.13	±	0.53	-1.13*	±	0.51	-0.47	±	0.60
C	4.87**	±	1.22	10.67**	±	1.17	5.53**	±	1.43
D	2.97**	±	0.58	6.20**	±	0.49	3.03**	±	0.75
	Gene effects in different models								
	Three parameters model (Jinks and Jones, 1958)								
M	53.46*	±	1.25	58.86**	±	1.01	52.20**	±	1.52
(d)	0.40*	±	0.15	-0.46*	±	0.22	-1.00**	±	0.18
(h)	-16.26**	±	3.04	-28.80**	±	2.30	-13.66**	±	3.64
	Three parameters model (Cavalli, 1952)								
M	47.50**	±	0.15	46.53**	±	0.18	46.21**	±	0.17
(d)	0.32*	±	0.15	-0.42**	±	0.14	-0.91**	±	0.16
(h)	-3.12**	±	0.31	-2.22**	±	0.35	-0.86**	±	0.33
χ2	27.98**			156.17**			19.31**		
	Six parameter model (Hayman, 1958)								
M	47.08**	±	0.24	48.00**	±	0.22	47.01**	±	0.31
(d)	0.01	±	0.30	-0.20	±	0.20	-0.80	±	0.43
(h)	-9.26**	±	1.21	-14.66**	±	1.06	-7.06**	±	1.55
(i)	-5.93**	±	1.16	-12.40**	±	0.99	-6.06**	±	1.51
(j)	-0.40	±	0.35	0.26**	±	0.30	0.20**	±	0.47
(l)	7.00**	±	1.72	14.13**	±	1.43	6.60**	±	2.24
	Six parameters model (Cavalli, 1952)								
M	53.46**	±	1.17	58.86**	±	1.01	52.20**	±	1.52
(d)	0.40*	±	0.19	-0.46*	±	0.22	-1.00**	±	0.18
(h)	-16.26**	±	2.76	-28.80**	±	2.30	-13.66**	±	3.64
(i)	-5.93**	±	1.16	-12.40**	±	0.99	-6.06**	±	1.51
(j)	-0.80	±	0.71	0.53	±	0.60	0.40	±	0.94
(l)	7.00**	±	1.72	14.13**	±	1.43	6.60**	±	2.24
Type of epistasis	**Duplicate**			**Duplicate**			**Duplicate**		
	Best fitting model (Cavalli, 1952)								
M		-		58.86**	±	1.01	52.35**	±	1.47
(d)		-		-0.32*	±	0.15	-0.97**	±	0.16
(h)		-		-28.78**	±	2.30	-14.14**	±	3.47
(i)		-		-12.35**	±	0.99	-6.22**	±	1.46
(j)	-				-			-	
(l)	-			14.12**	±	1.44	6.91**	±	2.12
χ2	-			0.78			0.18		

Table 4: Estimates of scaling tests and gene effects for number of node bearing first female flower of three crosses in bottle gourd

Scaling tests/gene effects	ABG 1 x DBG 5 (cross 1)			NDBG 132 x DBG 6 (cross 2)			Pusa Naveen x DBG 5 (cross 3)		
	Individual scaling test								
A	-6.27**	±	0.68	-2.07*	±	0.92	1.20	±	0.71
B	-4.40**	±	0.64	-1.60*	±	0.71	0.93	±	0.53
C	1.33	±	1.26	3.53**	±	1.33	5.00**	±	1.33
D	6.00**	±	0.65	3.60**	±	0.78	1.43*	±	0.70
	Gene effects in different models								
	Three parameters model (Jinks and Jones, 1958)								
M	26.06**	±	1.32	20.56**	±	1.58	18.13**	±	1.42
(d)	-1.06**	±	0.18	1.36**	±	0.17	1.00**	±	0.16
(h)	-31.40**	±	3.19	-17.96**	±	3.96	-5.46	±	3.35
	Three parameters model (Cavalli, 1952)								
M	13.52**	±	0.16	13.32**	±	0.15	15.46**	±	0.14
(d)	-1.33**	±	0.16	1.40**	±	0.16	1.02**	±	0.14
(h)	2.55**	±	0.32	0.05	±	0.31	-1.59**	±	0.28
$\chi 2$	137.59**			21.63**			15.69**		
	Six parameter model (Hayman, 1958)								
M	16.03**	±	0.26	14.30**	±	0.29	15.58**	±	0.29
(d)	-2.00**	±	0.38	1.13*	±	0.52	1.13**	±	0.38
(h)	-8.73**	±	1.35	-7.10**	±	1.60	-4.73**	±	1.44
(i)	-12.00**	±	1.31	-7.20**	±	1.57	-2.86*	±	1.41
(j)	-0.93*	±	0.42	-0.23	±	0.55	0.13	±	0.41
(l)	22.66**	±	1.98	10.86**	±	2.49	0.73	±	2.02
	Six parameters model (Cavalli, 1952)								
M	26.06**	±	1.32	20.56**	±	1.58	18.13**	±	1.42
(d)	-1.06**	±	0.18	1.36**	±	0.17	1.00**	±	0.16
(h)	-31.40**	±	3.19	-17.96**	±	3.96	-5.46	±	3.35
(i)	-12.00**	±	1.31	-7.20**	±	1.57	-2.86*	±	1.41
(j)	-1.86*	±	0.84	-0.46	±	1.10	0.26	±	0.82
(l)	22.66**	±	1.98	10.86**	±	2.49	0.73	±	2.02
Type of epistasis	**Duplicate**			**Duplicate**			**Duplicate**		
	Best fitting model (Cavalli, 1952)								
M		-		20.42**	±	1.54	17.62**	±	0.57
(d)		-		1.34**	±	0.16	1.02**	±	0.14
(h)		-		-17.55**	±	3.84	-4.25**	±	0.73
(i)		-		-7.05**	±	1.53	-2.36**	±	0.60
(j)	-				-		-		
(l)	-			10.59**	±	2.40	-		
$\chi 2$	-			0.18			0.32		

* and** Significant at 5 and 1 per cent levels, respectively

Table 5: Estimates of scaling tests and gene effects for number of node bearing first male flower of three crosses in bottle gourd

Scaling tests/gene effects	ABG 1 x DBG 5 (cross 1)			NDBG 132 x DBG 6 (cross 2)			Pusa Naveen x DBG 5 (cross 3)		
	Individual scaling test								
A	-4.18**	±	0.64	2.80**	±	0.66	3.27**	±	0.70
B	-2.53**	±	0.66	-0.13	±	0.71	1.40**	±	0.51
C	3.33**	±	1.03	-1.13	±	0.99	3.53**	±	0.98
D	5.00**	±	0.58	-1.90**	±	0.57	-0.57	±	0.54
	Gene effects in different models								
	Three parameters model (Jinks and Jones, 1958)								
m	20.90**	±	1.19	7.80**	±	1.15	11.03**	±	1.10
(d)	-0.70**	±	0.19	1.60**	±	0.17	1.10**	±	0.15
(h)	-24.90**	±	3.00	8.46**	±	3.01	5.96*	±	2.79
	Three parameters model (Cavalli, 1952)								
m	10.66**	±	0.16	11.59**	±	0.15	12.45**	±	0.13
(d)	-0.83**	±	0.17	1.80**	±	0.15	1.09**	±	0.13
(h)	1.73**	±	0.27	-1.64**	±	0.29	-0.53**	±	0.27
$\chi 2$	**83.48****			**22.97****			**30.24****		
	Six parameter model (Hayman, 1958)								
m	12.61**	±	0.21	10.41**	±	0.19	12.56**	±	0.20
(d)	-1.50**	±	0.39	3.06**	±	0.41	2.03**	±	0.37
(h)	-8.23**	±	1.20	2.00	±	1.18	0.16	±	1.12
(i)	-10.00**	±	1.17	3.80**	±	1.14	1.13	±	1.09
(j)	-0.80	±	0.43	1.46**	±	0.45	0.93*	±	0.40
(l)	16.66**	±	1.88	-6.46**	±	1.95	-5.80**	±	1.77
	Six parameters model (Cavalli, 1952)								
M	20.90**	±	1.19	7.80**	±	1.15	11.03**	±	1.10

(d)	-0.70**	±	0.19	1.60**	±	0.17	1.10**	±	0.15
(h)	-24.90**	±	3.00	8.46**	±	3.01	5.96*	±	2.79
(i)	-10.00**	±	1.17	3.80**	±	1.14	1.13	±	1.09
(j)	-1.60	±	0.87	2.93**	±	0.90	1.86*	±	0.80
(l)	16.66**	±	1.88	-6.46**	±	1.95	-5.80**	±	1.77
Type of epistasis	**Duplicate**			**Duplicate**			**Duplicate**		
	Best fitting model (Cavalli, 1952)								
M	20.93**	±	1.19		-		12.16**	±	0.15
(d)	-0.85**	±	0.17		-		1.10**	±	0.15
(h)	-24.98**	±	3.00		-		3.17**	±	0.75
(i)	-10.01**	±	1.17		-			-	
(j)		-			-		1.61*	±	0.76
(l)	16.72**	±	1.88		-		-4.14**	±	0.78
$\chi2$	3.33			-			1.08		

* and** Significant at 5 and 1 per cent levels, respectively

Table 6: Estimates of scaling tests and gene effects for vine length (m) of three crosses in bottle gourd

Scaling tests/gene effects	ABG 1 x DBG 5 (cross 1)			NDBG 132 x DBG 6 (cross 2)			Pusa Naveen x DBG 5 (cross 3)		
	Individual scaling test								
A	-0.23*	±	0.09	-0.39**	±	0.06	-0.38**	±	0.03
B	0.34**	±	0.04	-0.11**	±	0.02	-0.21**	±	0.04
C	0.03	±	0.10	0.49**	±	0.10	0.36**	±	0.11
D	-0.04	±	0.06	0.49**	±	0.06	0.47**	±	0.05
	Gene effects in different models								
	Three parameters model (Jinks and Jones, 1958)								
m	3.04**	±	0.12	4.53**	±	0.12	4.34**	±	0.11
(d)	-0.37**	±	0.01	-0.25**	±	0.08	-0.10**	±	0.01
(h)	0.39	±	0.32	-2.12**	±	0.28	-2.08**	±	0.24
	Three parameters model (Cavalli, 1952)								
m	3.14**	±	0.01	3.54**	±	0.01	3.33**	±	0.01
(d)	-0.40**	±	0.01	-0.25**	±	0.01	-0.13**	±	0.01
(h)	0.21**	±	0.02	0.34**	±	0.01	0.40**	±	0.02
$\chi2$	**76.26****			**81.70****			**156.17****		
	Six parameter model (Hayman, 1958)								
m	3.19**	±	0.02	3.84**	±	0.02	3.69**	±	0.02
(d)	-0.65**	±	0.04	-0.39**	±	0.03	-0.18**	±	0.02
(h)	0.19	±	0.12	-0.63**	±	0.12	-0.54**	±	0.11
(i)	0.08	±	0.12	-0.98**	±	0.12	-0.95**	±	0.11
(j)	-0.28**	±	0.04	-0.14**	±	0.03	-0.08**	±	0.02
(l)	-0.19	±	0.21	1.48**	±	0.16	1.54**	±	0.13
	Six parameters model (Cavalli, 1952)								
M	3.04**	±	0.12	4.53**	±	0.12	4.34**	±	0.11
(d)	-0.37**	±	0.01	-0.25**	±	0.07	-0.10**	±	0.01
(h)	0.39	±	0.32	-2.12**	±	0.28	-2.08**	±	0.24
(i)	0.08	±	0.12	-0.98**	±	0.12	-0.95**	±	0.11
(j)	-0.57**	±	0.09	-0.28**	±	0.07	-0.16**	±	0.05
(l)	-0.19	±	0.21	1.48**	±	0.17	1.54**	±	0.13
Type of epistasis	**Duplicate**			**Duplicate**			**Duplicate**		
	Best fitting model (Cavalli, 1952)								
M	3.13**	±	1.19		-			-	
(d)	-0.37**	±	0.17		-			-	
(h)	0.12**	±	3.00		-			-	
(i)		-			-			-	
(j)	-0.63**	±	0.07		-			-	
(l)		-			-			-	
$\chi2$	0.82						-		

* and** Significant at 5 and 1 per cent levels, respectively

Table 7: Estimates of scaling tests and gene effects for days to first picking of three crosses in bottle gourd

Scaling tests/gene effects	ABG 1 x DBG 5 (cross 1)			NDBG 132 x DBG 6 (cross 2)			Pusa Naveen x DBG 5 (cross 3)		
	Individual scaling test								
A	2.53**	±	0.80	2.13*	±	0.90	4.40**	±	0.86
B	1.13	±	0.79	0.20	±	0.88	2.87**	±	0.86
C	8.27**	±	1.96	6.60**	±	1.79	4.80**	±	1.57
D	2.30*	±	0.97	2.13*	±	0.82	-1.23	±	0.81
	Gene effects in different models								
	Three parameters model (Jinks and Jones, 1958)								
M	63.70**	±	1.97	64.66**	±	1.68	57.40**	±	1.63

(d)	0.96**	±	0.26	0.73	±	0.36	1.73**	±	0.23
(h)	-4.23	±	4.45	-6.13	±	3.97	10.86**	±	4.00
	Three parameters model (Cavalli, 1952)								
M	59.55**	±	0.23	60.83**	±	0.30	60.30**	±	0.21
(d)	1.14**	±	0.22	1.08**	±	0.27	1.75**	±	0.21
(h)	1.67**	±	0.42	0.31	±	0.54	-0.42	±	0.42
χ2	**22.56****			**17.40****			**32.29****		
	Six parameter model (Hayman, 1958)								
M	61.81**	±	0.43	62.08**	±	0.35	60.40**	±	0.32
(d)	1.66**	±	0.43	1.70**	±	0.42	2.50**	±	0.49
(h)	-3.30	±	2.00	-4.20*	±	1.73	1.13	±	1.68
(i)	-4.60*	±	1.95	-4.26*	±	1.64	2.46	±	1.62
(j)	0.70	±	0.50	0.96	±	0.56	0.76	±	0.54
(l)	0.93	±	2.61	1.93	±	2.46	-9.73**	±	2.53
	Six parameters model (Cavalli, 1952)								
m	63.70**	±	1.97	64.66**	±	1.68	57.40**	±	1.63
(d)	0.96**	±	0.26	0.73*	±	0.36	1.73**	±	0.23
(h)	-4.23	±	4.45	-6.13	±	3.97	10.86**	±	4.00
(i)	-4.60*	±	1.95	-4.26**	±	1.64	2.46	±	1.62
(j)	1.40	±	1.01	1.93	±	1.12	1.53	±	1.09
(l)	0.93	±	2.61	1.93	±	2.46	-9.73**	±	2.53
Type of epistasis	**Duplicate**			**Duplicate**			**Duplicate**		
	Best fitting model (Cavalli, 1952)								
m	63.04**	±	0.80	63.46**	±	0.77	59.83**	±	0.23
(d)	1.15**	±	0.22	1.18**	±	0.27	1.86**	±	0.21
(h)	-2.68*	±	1.05	-3.12**	±	1.08	5.08**	±	1.12
(i)	-3.96**	±	0.87	-3.25**	±	0.88		-	
(j)	-		-		-			-	
(l)	-		-		-		-6.37**	-	1.20
χ2	2.05			3.79			4.15		

* and** Significant at 5 and 1 per cent levels, respectively

Table 8: Estimates of scaling tests and gene effects for fruit length (cm) of three crosses in bottle gourd

Scaling tests/gene effects	ABG 1 x DBG 5 (cross 1)			NDBG 132 x DBG 6 (cross 2)			Pusa Naveen x DBG 5 (cross 3)		
	Individual scaling test								
A	6.80**	±	1.14	1.53*	±	0.67	-3.00**	±	0.86
B	-9.40**	±	0.60	-3.47**	±	0.45	-0.47	±	0.88
C	4.93**	±	1.29	1.67	±	1.07	6.47**	±	1.61
D	3.77**	±	0.81	1.80**	±	0.54	4.97**	±	0.88
	Gene effects in different models								
	Three parameters model (Jinks and Jones, 1958)								
m	49.33**	±	1.64	41.66**	±	1.10	41.76**	±	1.78
(d)	8.40**	±	0.18	1.73**	±	0.22	-1.56**	±	0.19
(h)	-14.20**	±	4.23	-6.06*	±	2.66	-19.90**	±	4.32
	Three parameters model (Cavalli, 1952)								
m	41.05**	±	0.17	37.56**	±	0.17	31.86**	±	0.18
(d)	9.77**	±	0.17	2.99**	±	0.17	-1.71**	±	0.18
(h)	3.37**	±	0.31	3.21**	±	0.29	3.41**	±	0.36
χ2	**362.53****			**86.12****			**36.39****		
	Six parameter model (Hayman, 1958)								
m	44.76**	±	0.28	40.01**	±	0.22	35.16**	±	0.35
(d)	16.50**	±	0.58	4.23**	±	0.30	-2.83**	±	0.53
(h)	-4.06*	±	1.66	-0.53	±	1.12	-6.50**	±	1.81
(i)	-7.53**	±	1.63	-3.60**	±	1.08	-9.93**	±	1.77
(j)	8.10**	±	0.61	2.50**	±	0.38	-1.26*	±	0.56
(l)	10.13**	±	2.69	5.53**	±	1.63	13.40**	±	2.67
	Six parameters model (Cavalli, 1952)								
M	49.33**	±	1.64	41.66**	±	1.10	41.76**	±	1.78
(d)	8.40**	±	0.18	1.73**	±	0.22	-1.56**	±	0.19
(h)	-14.20**	±	4.23	-6.06*	±	2.66	-19.90**	±	4.32
(i)	-7.53**	±	1.63	-3.60**	±	1.08	-9.93**	±	1.77
(j)	16.20**	±	1.23	5.00**	±	0.76	-2.53*	±	1.13
(l)	10.13**	±	2.69	5.53**	±	1.63	13.40**	±	2.67
Type of epistasis	Duplicate			Duplicate			Duplicate		

* and** Significant at 5 and 1 per cent levels, respectively

Table 9: Estimates of scaling tests and gene effects for fruit equatorial diameter (cm) of three crosses in bottle gourd

Scaling tests/gene effects	ABG 1 x DBG 5 (cross 1)			NDBG 132 x DBG 6 (cross 2)			Pusa Naveen x DBG 5 (cross 3)		
	Individual scaling test								
A	-0.62**	±	0.14	-0.87**	±	0.16	0.21	±	0.27
B	0.68**	±	0.17	-0.04	±	0.14	-0.75**	±	0.18
C	-2.01**	±	0.26	-2.41**	±	0.30	-2.10**	±	0.42
D	-1.03**	±	0.01	-0.75**	±	0.02	-0.78**	±	0.02
	Gene effects in different models								
	Three parameters model (Jinks and Jones, 1958)								
M	3.50**	±	0.08	4.91**	±	0.05	4.98**	±	0.10
(d)	-0.28**	±	0.08	-0.30**	±	0.03	0.27*	±	0.09
(h)	4.57**	±	0.27	2.45**	±	0.21	3.02**	±	0.36
	Three parameters model (Cavalli, 1952)								
M	5.50**	±	0.06	6.00**	±	0.01	6.58**	±	0.01
(d)	-0.74**	±	0.01	-0.73**	±	0.01	0.32**	±	0.01
(h)	0.01	±	0.12	0.33	±	0.03	-0.52**	±	0.03
χ2	7156.28**			1172.64**			1338.73**		
	Six parameter model (Hayman, 1958)								
M	5.26**	±	0.01	5.99**	±	0.01	6.23**	±	0.01
(d)	-0.94**	±	0.01	-0.71**	±	0.01	0.74**	±	0.02
(h)	2.45**	±	0.14	1.86**	±	0.15	2.00**	±	0.22
(i)	2.06**	±	0.02	1.50**	±	0.04	1.55**	±	0.04
(j)	-0.65**	±	0.08	-0.41**	±	0.03	0.47**	±	0.10
(l)	-2.12**	±	0.27	-0.59	±	0.30	-1.01*	±	0.43
	Six parameters model (Cavalli, 1952)								
M	3.50**	±	0.08	4.91**	±	0.05	4.98**	±	0.10
(d)	-0.28**	±	0.08	-0.30**	±	0.03	0.27**	±	0.09
(h)	4.57**	±	0.27	2.45**	±	0.21	3.02**	±	0.36
(i)	2.06**	±	0.02	1.50**	±	0.04	1.55**	±	0.04
(j)	-1.30**	±	0.16	-0.83**	±	0.07	0.95**	±	0.19
(l)	-2.12**	±	0.27	-0.59	±	0.30	-1.01*	±	0.43
Type of epistasis	Duplicate			Duplicate			Duplicate		
	Best fitting model (Cavalli, 1952)								
M		-		4.94**	±	0.05		-	
(d)		-		-0.28**	±	0.03		-	
(h)		-		2.09**	±	0.10		-	
(i)		-		1.47**	±	0.04		-	
(j)		-		-0.86**	±	0.07		-	
(l)		-			-			-	
χ2	-			3.44			-		

* and** Significant at 5 and 1 per cent levels, respectively

Table 10: Estimates of scaling tests and gene effects for number of fruits per plant of three crosses in bottle gourd

Scaling tests/gene effects	ABG 1 x DBG 5 (cross 1)			NDBG 132 x DBG 6 (cross 2)			Pusa Naveen x DBG 5 (cross 3)		
	Individual scaling test								
A	-1.00	±	0.64	-1.40**	±	0.50	-0.73	±	0.71
B	-0.67	±	0.66	0.13	±	0.58	-0.33	±	0.68
C	-2.00	±	1.06	-2.53**	±	0.91	-1.93	±	1.07
D	-0.17	±	0.52	-0.63	±	0.37	-0.43	±	0.57
	Gene effects in different models								
	Three parameters model (Jinks and Jones, 1958)								
M	4.26**	±	1.05	3.26**	±	0.75	4.40**	±	1.16
(d)	0.53**	±	0.18	-0.06	±	0.14	0.53**	±	0.17
(h)	-0.13	±	2.70	2.06	±	1.97	1.40	±	3.00
	Three parameters model (Cavalli, 1952)								
M	4.47**	±	0.16	4.44**	±	0.13	5.16**	±	0.15
(d)	0.55**	±	0.15	-0.22	±	0.12	0.50**	±	0.15
(h)	0.50**	±	0.13	0.16	±	0.29	0.49**	±	0.13
χ2	4.38			14.76**			3.52		
	Six parameter model (Hayman, 1958)								
m		-		4.30**	±	0.13	-		
(d)		-		-0.83**	±	0.26	-		
(h)		-		2.06*	±	0.83	-		
(i)		-		1.26	±	0.74	-		
(j)		-		-0.76*	±	0.30	-		
(l)		-		0.01	±	1.38	-		
	Six parameters model (Cavalli, 1952)								
m		-		3.26**	±	0.75	-		

(d)		-		-0.06	±	0.14	-		
(h)		-		2.06	±	1.97	-		
(i)		-		1.26	±	0.74	-		
(j)		-		-1.53*	±	0.60	-		
(l)		-		0.01	±	1.38	-		
Type of epistasis	-			Complementary			-		

* and** Significant at 5 and 1 per cent levels, respectively

Table 11: Estimates of scaling tests and gene effects average fruit weight per plant (kg) of three crosses in bottle gourd

Scaling tests/gene effects	ABG 1 x DBG 5 (cross 1)			NDBG 132 x DBG 6 (cross 2)			Pusa Naveen x DBG 5 (cross 3)		
	Individual scaling test								
A	-0.16**	±	0.05	-0.05	±	0.03	-0.06*	±	0.02
B	-0.19**	±	0.03	-0.03	±	0.02	-0.02	±	0.02
C	-0.34**	±	0.08	-0.01	±	0.04	-0.13**	±	0.04
D	0.00	±	0.03	0.04*	±	0.01	-0.02	±	0.01
	Gene effects in different models								
	Three parameters model (Jinks and Jones, 1958)								
m	0.76**	±	0.07	0.70**	±	0.03	0.62**	±	0.03
(d)	0.02	±	0.02	0.03**	±	0.01	0.01	±	0.01
(h)	-0.30	±	0.18	-0.16*	±	0.08	0.08	±	0.08
	Three parameters model (Cavalli, 1952)								
m	0.70**	±	0.01	0.62**	±	0.01	0.64**	±	0.01
(d)	0.02	±	0.01	0.03**	±	0.01	-0.01	±	0.01
(h)	0.03	±	0.02	0.05**	±	0.02	0.04**	±	0.01
χ2	29.35**			7.03*			8.30*		
	Six parameter model (Hayman, 1958)								
m	0.70**	±	0.01	0.66**	±	0.01	0.66**	±	0.01
(d)	0.03	±	0.02	0.02*	±	0.01	-0.01	±	0.01
(h)	0.05	±	0.07	-0.01	±	0.03	0.11**	±	0.03
(i)	-0.01	±	0.07	-0.07*	±	0.03	0.04	±	0.03
(j)	0.01	±	0.02	-0.01	±	0.01	-0.02	±	0.01
(l)	0.35**	±	0.12	0.15*	±	0.06	0.03	±	0.06
	Six parameters model (Cavalli, 1952)								
m	0.76**	±	0.07	0.70**	±	0.03	0.61**	±	0.03
(d)	0.02	±	0.02	0.03**	±	0.01	0.01	±	0.01
(h)	-0.30	±	0.18	-0.16*	±	0.08	0.08	±	0.08
(i)	-0.01	±	0.07	-0.07*	±	0.03	0.05	±	0.03
(j)	0.02	±	0.05	-0.02	±	0.02	-0.04	±	0.02
(l)	0.35**	±	0.12	0.15**	±	0.06	0.04	±	0.06
Type of epistasis	Duplicate			Duplicate			Complementary		
	Best fitting model (Cavalli, 1952)								
m	0.76**	±	0.01		-		-		
(d)	0.02*	±	0.01		-		-		
(h)	-0.29**	±	0.06		-		-		
(i)	-				-		-		
(j)	-			-			-		
(l)	0.35**	±	0.06		-		-		
x^2	0.09			-			-		

* and** Significant at 5 and 1 per cent levels, respectively

Table 12: Estimates of scaling tests and gene effects for days to last picking of three crosses in bottle gourd

Scaling tests/gene effects	ABG 1 x DBG 5 (cross 1)			NDBG 132 x DBG 6 (cross 2)			Pusa Naveen x DBG 5 (cross 3)		
	Individual scaling test								
A	4.33**	±	1.22	2.13*	±	0.89	4.40**	±	0.90
B	2.27*	±	0.89	0.87	±	1.01	2.87**	±	0.86
C	9.80**	±	2.29	6.67**	±	1.78	5.20**	±	1.58
D	1.60	±	1.24	1.83*	±	0.86	-1.03	±	0.82
	Gene effects in different models								
	Three parameters model (Jinks and Jones, 1958)								
M	123.10**	±	2.51	124.06**	±	1.75	117.73**	±	1.66
(d)	0.70*	±	0.33	0.73*	±	0.35	1.66**	±	0.23
(h)	-1.03	±	5.87	-4.26	±	4.24	10.13*	±	4.08
	Three parameters model (Cavalli, 1952)								
M	120.72**	±	0.28	120.93**	±	0.30	120.25**	±	0.21
(d)	0.53	±	0.28	0.85**	±	0.28	1.67**	±	0.21
(h)	-1.53**	±	0.42	0.34	±	0.54	-0.38	±	0.42
χ2	30.18**			15.82**			31.40**		
	Six parameter model (Hayman, 1958)								

M	121.73**	±	0.53	122.10**	±	0.35	120.46**	±	0.32
(d)	1.73*	±	0.65	1.36**	±	0.49	2.43**	±	0.51
(h)	-4.43	±	2.53	-3.60*	±	1.80	0.80	±	1.70
(i)	-3.20	±	2.49	-3.66*	±	1.72	2.06	±	1.64
(j)	1.03	±	0.73	0.63	±	0.60	0.76	±	0.56
(l)	-3.40	±	3.47	0.66	±	2.65	-9.33**	±	2.58
	Six parameters model (Cavalli, 1952)								
m	123.10**	±	2.51	124.06**	±	1.75	117.73**	±	1.66
(d)	0.70*	±	0.33	0.73*	±	0.35	1.66**	±	0.23
(h)	-1.03	±	5.87	-4.26	±	4.24	10.13*	±	4.08
(i)	-3.20	±	2.49	-3.66*	±	1.72	2.06	±	1.64
(j)	2.06	±	1.46	1.26	±	1.21	1.53	±	1.12
(l)	-3.40	±	3.47	0.66	±	2.65	-9.33**	±	2.58
Type of epistasis	**Complementary**			**Duplicate**			**Duplicate**		
	Best fitting model (Cavalli, 1952)								
m	125.17**	±	0.89	123.69**	±	0.78	119.76**	±	0.23
(d)	0.87**	±	0.29	0.95**	±	0.29	1.79**	±	0.21
(h)	-6.48**	±	1.02	-3.24**	±	1.08	5.21**	±	1.13
(i)	-5.29**	±	1.00	-3.36**	±	0.87		-	
(j)	-				-			-	
(l)	-				-		-6.45**	±	1.21
χ2	2.32			1.11			3.23		

* and** Significant at 5 and 1 per cent levels, respectively

Table 13: Estimates of scaling tests and gene effects for fruit yield per plant (kg) of three crosses in bottle gourd

Scaling tests/gene effects	ABG 1 x DBG 5 (cross 1)			NDBG 132 x DBG 6 (cross 2)			Pusa Naveen x DBG 5 (cross 3)		
	Individual scaling test								
A	-0.26	±	0.14	0.12	±	0.10	-0.39*	±	0.15
B	-0.21	±	0.12	-0.28**	±	0.10	0.12	±	0.16
C	-0.35	±	0.24	0.03	±	0.19	-0.21	±	0.31
D	0.06	±	0.06	0.10*	±	0.04	0.03	±	0.05
	Gene effects in different models								
	Three parameters model (Jinks and Jones, 1958)								
m	3.47**	±	0.14	3.62**	±	0.09	3.31**	±	0.11
(d)	-0.15**	±	0.04	-0.01	±	0.02	-0.02	±	0.02
(h)	-0.41	±	0.37	-0.31	±	0.27	-0.04	±	0.31
	Three parameters model (Cavalli, 1952)								
m	3.32**	±	0.04	3.44**	±	0.02	3.30**	±	0.02
(d)	-0.17**	±	0.03	0.06**	±	0.02	-0.15**	±	0.02
(h)	0.16	±	0.08	0.16	±	0.05	0.05	±	0.05
χ2	4.07			26.02**			17.60**		
	Six parameter model (Hayman, 1958)								
m		-		3.55**	±	0.01	3.37**	±	0.02
(d)		-		0.19**	±	0.03	-0.28**	±	0.03
(h)		-		0.03	±	0.13	0.28	±	0.18
(i)		-		-0.19*	±	0.09	-0.06	±	0.11
(j)		-		0.20**	±	0.04	-0.25**	±	0.04
(l)		-		0.34	±	0.23	0.33	±	0.33
	Six parameters model (Cavalli, 1952)								
m		-		3.62**	±	0.09	3.31**	±	0.11
(d)		-		-0.02	±	0.02	-0.02	±	0.02
(h)		-		-0.31	±	0.27	-0.04	±	0.31
(i)		-		-0.19*	±	0.09	-0.06	±	0.11
(j)		-		0.40**	±	0.08	-0.51**	±	0.08
(l)		-		0.34	±	0.23	0.33	±	0.33
Type of epistasis	-			**Duplicate**			**Duplicate**		
	Best fitting model (Cavalli, 1952)								
m		-			-		-		
(d)		-			-		-		
(h)		-			-		-		
(i)		-			-		-		
(j)	-				-		-		
(l)	-				-		-		
χ2	-			-			-		

* and** Significant at 5 and 1 per cent levels, respectively

Conclusion

It would be concluded from the present study that fruit yield and its component traits studied in three bottle gourd crosses were governed by additive, dominance, digenic, epistasis and digenic epistasis gene effects along with duplicate type of gene action. When additive as well as non-additive gene effects are involved, a breeding scheme efficient in exploiting both types of gene effects should be employed. Bi-parental mating could be followed which would facilitate exploitation of both additive and non-additive gene effects simultaneously for genetic improvement of fruit yield and its component traits in bottle gourd.

References

1. Cavalli LL. An analysis of linkage in quantitative inheritance, Quantitative inheritance. H.M.S.O. London, 1952, 135-144.
2. Cockerham CC. Partitions of hereditary variances for various genetic models. Genetics. 1959; 44:1141-1148.
3. Gautam DK, Yadav GC. Gene action for growth, yield and quality traits in bottle gourd [*Lagenaria siceraria* (Mol.) Standl]. J Pharmacog. Phytochem. 2017; 6(4):84-88.
4. Hayman BI. The separation of epistatic from additive and dominance variation in generation means. Heredity. 1958; 12:371-390.
5. Jinks JL, Jones RM. Estimation of the components of heterosis. Genetics. 1958; 43(2):223-224.
6. Mather K. Biometrical Genetics. Dover Publication, Inc., New York, 1949.
7. Mather K, Jinks JL. Biometrical Genetics. 3rd Edition. Chapman and Hall, London, 1982.
8. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi, 1985.
9. Patel NK. Genetic analysis for fruit yield and its components in bottle gourd [*Lagenaria siceraria* (Mol.) Standl]. M. Sc. (Agri.) Thesis (Unpublished) Submitted to Anand Agricultural University, Anand, 2010.
10. Wani KP, Ahmed N, Afroza B, Hussain K. Line x tester analysis for combining ability in bottle gourd under temperate condition of Kashmir Valley. Indian J Hort. 2009; 66(4):476-482.